users of the system logging in and submitting content to the system regularly. It was only during the sixth week that a few students began sharing their content to the community.

From statistics, it is quite obvious that had the prototype usage been further recorded, more students would have contributed to the network and by time will surpass the amount of content contributed by the staff and faculty members. Ramifications for what may result in too much information or inappropriate content was not discussed or thoroughly planned at this stage.

Another set of data that was of interest is the number of interactions during the thirteen weeks categorized by weekdays. The average number of interactions per day is 9.29 postings and the popular days to post content are Thursday, Friday, Wednesday, Tuesday, and Monday consecutively (Figure 5.2). This is due to the fact that most Thursdays are set for faculty meetings and thesis reviews so not many classes are scheduled during this day. Most students are present during this day to work on studio projects that are usually submitted on Fridays so they tend to browse the board and or make contributions throughout the day. Similarly, instructors and staff submit most of their content during this day simply because they have the spare time only on this particular day.

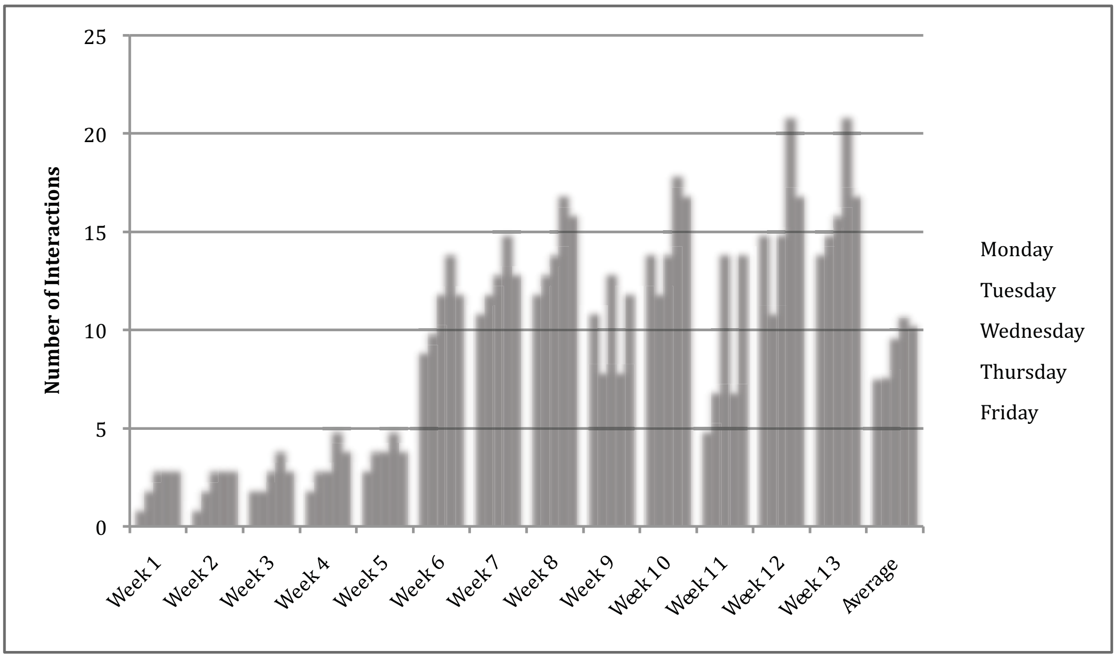

Figure 5.2 Number of interactions performed in each week with Thursday having a maximum total of 141 while Monday having only 100 interactions in total.

Looking at the number and types of interactions with the board itself (Figure 5.3), statistics reveals that browsing is the most common interaction that users conduct with an average of 39.54 interactions per week and 514 interactions in total. Browsing activities consists of clicking on the main content window, clicking on the preview thumbnails, or scrolling through any of the content within the interface. The second most common interaction is posting content in which accounts for 4.69 interactions per week and 61 postings in total. In spite of this, when compared to the number of browsing, the number of postings is still relatively low even when combined with other interactions. The least common type of interaction is the email feature where users send an average of 1.08 emails per week and 14 emails in 13 weeks. The voting interaction is also low accounting for only 15 votes in 13 weeks or an average of 1.15 votes per week. However, it is also encouraging to see the rise of email interactions in the last four weeks which suggests that it may be a valuable feature when users become more accustomed to the system.

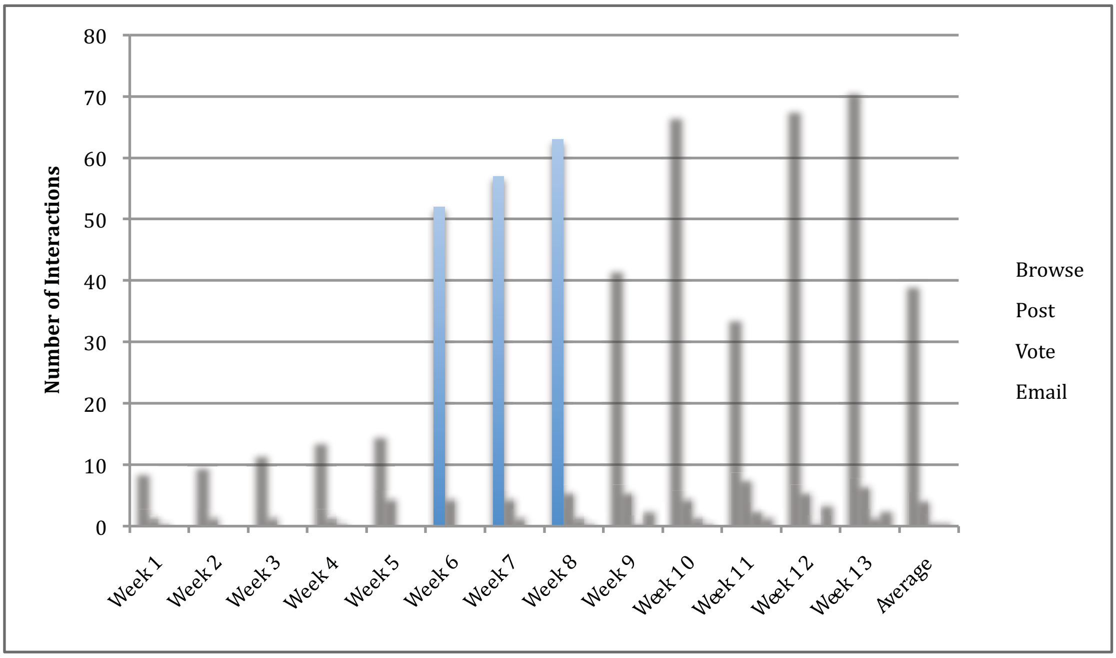

Figure 5.3 The amount of interaction types conducted in each week. Out of 604 interactions in 13 weeks, browsing accounts for 85%, posting accounts for 10%, voting at 2.6%, and email at 2.4% of all interactions.

When distinguishing the types of information that was being posted by users, 23 postings were images, 22 were plain text, 10 were text announcements, 4 were video, and 2 were text alerts (Figure 5.4).

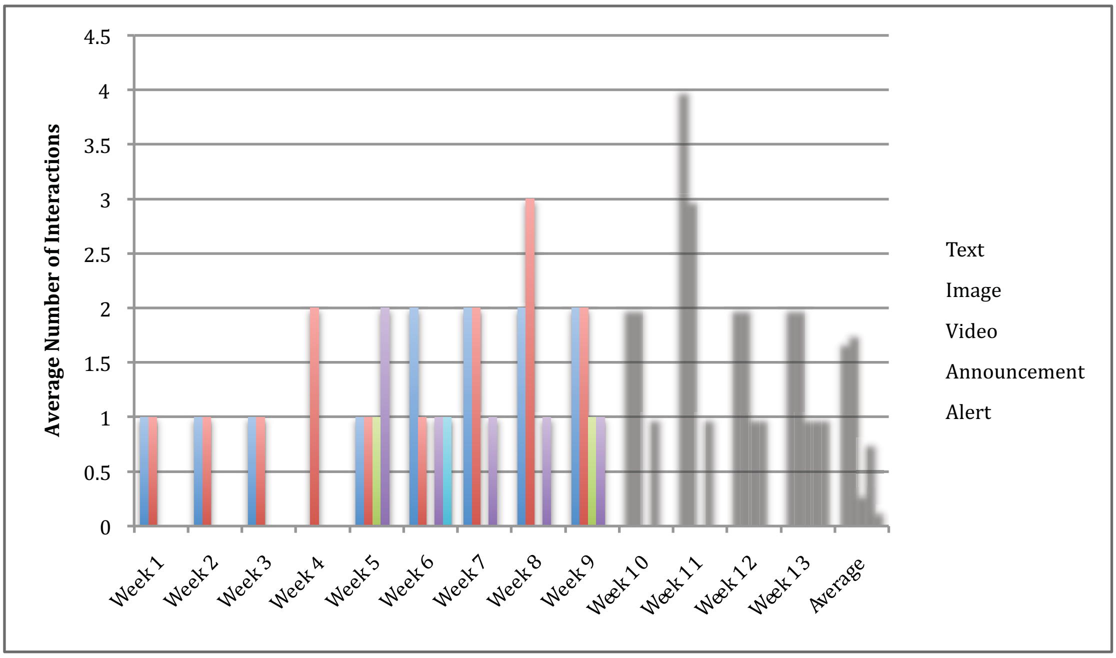

Figure 5.4 The types of content posted on the interactive bulletin board. Out of a total of 61 postings, images account for 37%, text 36%, announcement 16%, video 7%, and alerts 4%.

Due to limited time for testing, no significant patterns could be defined from these statistics but it is fair to conclude that if users become more familiar with the system features and its user interface, the variety of the content types should increase in time.

For the last set of statistics, the timeframe from which users prefer to use the system is observed. A standard timetable from Silpakorn University divides a normal academic day into eight slots from 8:30 am to 7:30 pm (Figure 5.5). Each university faculty should have a different pattern which should also be unique to the learning process of that particular faculty. For the faculty of architecture, on average users prefer to interact with the system between late morning and early afternoon and especially on Thursday. This suggests that if an instructor or staff would like to make public announcements, it should be done before this time slot and before Thursday if possible.

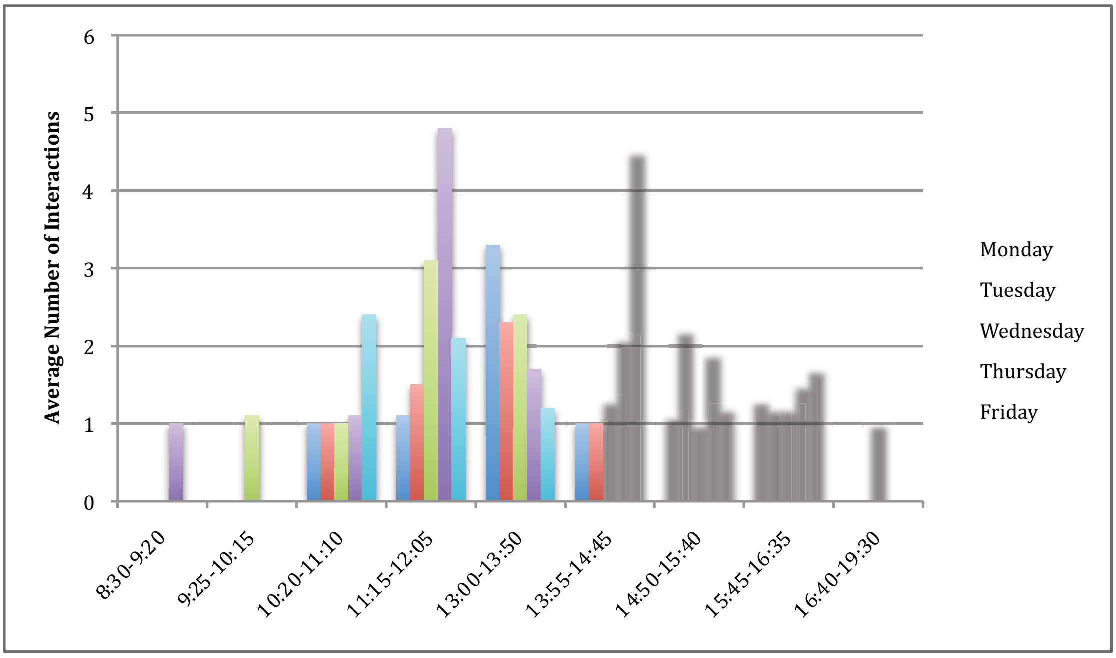

Figure 5.5 Average number of interactions grouped by the faculty timetable.

5.2 USER FEEDBACK

In addition to remote monitoring of the system usage, an informal interview was conducted to gather direct user feedback and suggestions for future revisions of the system. When asked about the user interface of the system and its usability, most users had no problem navigating or finding information when browsing through its content. However, for features specific for administration users, some users required guidance and reminding of some functions and settings which is a normal occurrence for any software application user.

The remaining questions besides the usability of the system was to validate whether such system could promote or encourage interactions among people within the faculty of architecture. The result of user feedback was quite encouraging. Out of 124 correspondents, 10 strongly agreed that the system helped strengthened the interaction between staff, students, and instructors from both campuses. Another 110 agreed with the same claim, while 1 was neutral, and the remaining 3 disagreed (Figure 5.6).

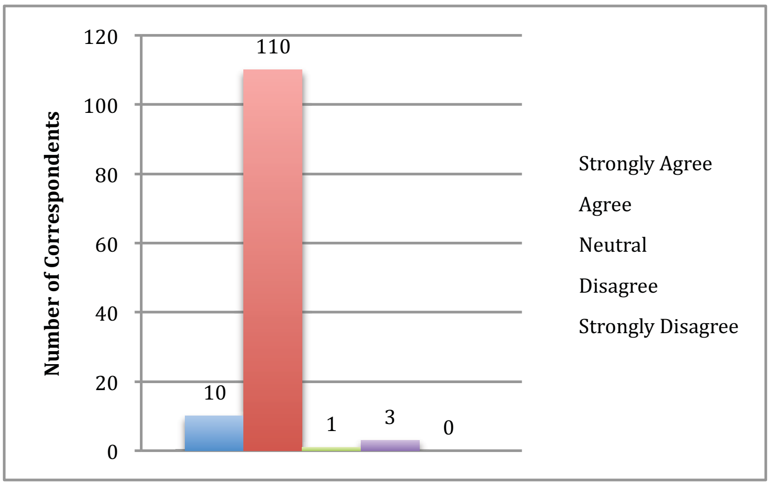

Figure 5.6. User feedback of the Interactive Bulletin Board prototype (FACE Network) after 3 months of deployment and real use, users agreed that the system encouraged more interaction among staff, students, and instructors between the two campuses.

Other questions that were asked confirmed all the design and implementation criteria of the system prototype according to the first user requirement study. With this data collection and user feedback, findings of the research can be analyzed and concluded.

5.3 DATA ANALYSIS

From the system database, certain patterns have emerged allowing assumptions about user behavior of the system to be made. Weekly usage of the system shows that every Thursdays have the highest system usage out of the week while Mondays have the least amount of daily usage. This pattern is synonymous with student and instructor schedules in the week and specific to users of the tested faculty. In the Faculty of Architecture, most Thursdays are scheduled with architectural thesis reviews for fifth year students which are conducted once every month. People in the faculty will be present on this day and therefore activities and usage of the system is apparent when more people are present to interact with one another.

The types of information that is commonly posted are text, images, and text announcements due to the fact that it is more convenient and less time-consuming for users to execute. However, video and multimedia content were also a favorite type when asked about what the strengths of this interactive bulletin board was.

The most common function used by most users is the browse content function. The numbers are constantly high and continue to grow higher as time goes by. The other functions are posting content but the numbers show a slow start but gradual growth in number of postings during late stages of the experiment.

Finally, when users were asked to give feedback about their perception of the system and what they thought about replacing existing board with the interactive bulletin board. There was a mix of agrees and disagrees but all in all, users confirmed that it was not a solution to replace existing boards but to enhance existing boards with features and content that is not possible with existing boards. They do, however, feel that the implementation of such interactive bulletin board has drawn more users to interact with each other not only in front of the interactive bulletin board but asynchronously when sending information of the posting to their friends and colleagues email addresses.

The activity of hanging out in front of the administration office not only provides people with a updated information, the board can also help initiate conversations about certain interest or events that people may share or have in common. This has certainly impacted the way people utilize the space and forever change the way we perceive the bulletin board furniture of the future.

5.4 ENCOUNTERED PROBLEMS

During the prototype development and implementation stages, several problems were encountered that became more than just challenges but setbacks to the entire development process. The following are major setbacks that had to be resolved along the way with explanations and solutions that were implemented.

Deployment Site

The faculty of architecture was undergoing a major renovation which was part of the University's planned policy for the Tha Pra and Sanam Chandra campuses. Construction began in late 2007, but unfortunately the installation site for the prototype system was closed for an entire academic year so installation and testing of the prototype system was not possible until the completion of the renovation in early 2009. This setback caused delays not only to the testing of the system but to the hardware development as well.

System Features

Due to recent changes in university policies for Internet activities to comply with the new IT regulations set by the Ministry of Information and Communication Technology, the web camera feature was not implemented during the testing of the system. Any web camera activities were disabled and banned throughout the university therefore having live video feed was absolutely impossible even from within the same campus. The web camera feature was disabled and not used during the prototype experiments.

User Interface Design

The size and resolution of the user interface was not thoroughly tested with client PCs and the actual LCD display during the development phase of the interface design. The mismatch between the user interface size in pixels, the graphics card resolution, and the LCD display resolution and aspect ratio, caused the fixed height of the interface to be longer than what the graphics card and LCD display could display. It was intended that the screen size be fixed so all components of the system can be viewed at once. This was not possible when the user is forced to scroll down to view the preview window and announcement messages near the bottom of the screen. In plain sight, no users actually know that there was content beyond the visible borders of the frame.

Hardware Development

The most problematic hardware during development was the customized stand. The footprint of the stand was slightly longer than expected due to miscommunications between the designer and metal worker. It took up more space in the front of the display and caused users to stand further to the back to interact with the system. The LCD display locking mechanism that was supposed to be easily lockable and detachable was also not implemented due to miscommunications as well. But since the stand was not used for experimentation, the problems were still good design lessons.

6. CONCLUSION

6.1 SUMMARY

Intelligent roomware system is a research project that proposes the utilization of existing hardware, furniture, flat surfaces, or architectural elements with enhanced information technology to suit certain needs of users throughout time. From this concept, a series of prototypes were developed and a design framework was defined as a set of guidelines to build and implement such systems more effectively. One particular prototype, the FACE Network, was built on the basic requirements set by the target users and designed according to the design framework. After three months of real use the system was evaluated and its data was analyzed. User feedback was also collected to analyze how well the prototype performed and whether the underlying concept actually worked for the targeted users. The results verified the hypothesis that was set by this research and future planning of new roomware systems can be deployed according to these findings.

6.2 RESEARCH FINDINGS

The first and foremost research finding of this research project is the design framework that has been defined by analyzing prior research and testing of roomware prototypes. The framework consists of five distinct qualities or attributes that intelligent roomware systems should embody. The first is “Physical Presence” which allows users to interact and receive feedback through various body senses intuitively. “Multiple and Flexible Functions” is the second attribute which provides users with adaptability of interactions and functions within the system. Third is “User Engagement” which encourages users to interact with the system with little or no prior training. “Digital Information Output” is the fourth attribute in the framework. Information provided by the intelligent roomware must be digital information so as to obtain and update information quickly and accurately. The last attribute is “Scalable Tangible Interactions” which requires that tangible interactions be the main means of communicating with the system. But because the extended scale of such roomware, the tangible interactions must also be scalable to fit the different sized roomware appropriately.

The second research finding relies on data gathered from user interactions recorded during the test run of the prototype. Statistics revealed some interesting patterns of how the prototype was used. For most users, browsing was the main type of interaction accounting for 85% of all interactions. The second interaction type was posting information which was performed only by administration users accounting for 10% of interactions. The remaining interaction types were voting and emailing when combined accounted for only 5% of all interactions. The only pattern that became obvious was the email feature that showed gradual increase during the last month of system deployment. This suggests that with time, more interactions that involve sharing information or contributing information will occur more often in the community.

The third set of findings is information received from user feedback after the experiment has concluded. When asked whether the interactive bulletin board was useful in obtaining information (browsing, viewing votes, emailing content), the answer was yes without doubt. Users were asked if they thought that the interactive bulletin board could someday replace the existing physical bulletin board. The answers were split but most users see the potential of interactive bulletin boards becoming a new type of furniture in its own right and do not think they will be used to replace all existing boards. Another interesting question is what users think the greatest benefit for using this interactive bulletin board would be. Multimedia content display, interactivity of the board, convenient storage and browsing, large attractive content, creates lively space, are among answers users replied. When asked whether the interactive bulletin board can be used as a tool to promote a sharing learning atmosphere in the University, the answer was yes and most likely.

From all the research findings, it is fair to say that the design framework for Intelligent Roomware System is validated through user trial and the hypothesis is also confirmed that such system can impact the way people work and promote social relationships among people in the work environment.

6.3 FUTURE WORK

With promising results, the future work of this research project can continue to explore more roomware products that can be further enhanced, implemented, and tested similar to the prototype developed for this research. A larger much more complex scale of roomware is also a suitable direction for this research to pursue in the future. However, more elaborate user studies along with long-term experiments must also be taken to account for future work in this area. If roomware designs were more diverse, problems in many roomware designs can provide a better understanding of future user requirements and along the way, validate or add-on to existing design frameworks as contribution to the knowledge of design technology.

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RESEARCH OUTPUT

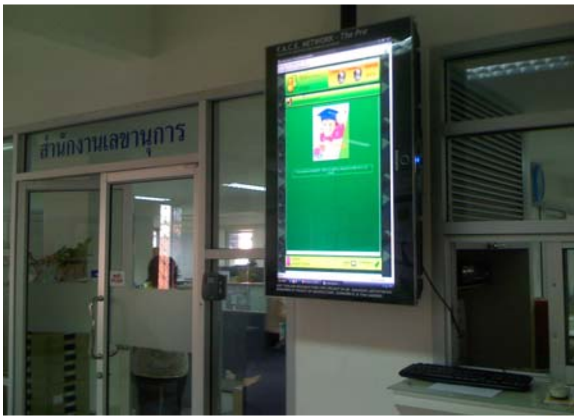
1. PUBLICATIONS

Back, M., Lertsithichai, S., Chiu, P., Boreczky, J., Foote, J., Kimber, D., Liu, Q. and Matsumoto, T. (2008). *Rethinking the Podium*, in Dillenbourg, P., Huang, J., and Cherubini, M. (Eds.) *Interactive Artifacts and Furniture Supporting Collaborative Work and Learning*. Springer 2008, pp. 97-110.

Khampanya, R. and Lertsithichai, L. (2009). *TangiDESK: A Tangible Interface Prototype for Urban Design and Planning*. CAADRIA 2009 Full Paper.

2. APPLICATION

Final research prototype, “FACE Network,” developed and deployed as the first Interactive Bulletin Board for internal use at the Faculty of Architecture at Silpakorn University Tha Pra campus. The system has been in service since May 4^{th} 2009 and is currently installed in front of the administration office on the second floor of the Faculty of Architecture building.



3. INTELLECTUAL PROPERTY

The research prototype system titled “Interactive Bulletin Board” was submitted to the Department of Intellectual Property, Ministry of Commerce as a Thai Patent application filed on August 31, 2009 with the Thai title as “ระบบบอร์ดประชาสัมพันธ์อิเล็คทรอนิกส์.”

APPENDIX

1. USER STUDY QUESTIONNAIRE

แบบสอบถามเกี่ยวกับบอร์ดประชาสัมพันธ์ในคณะฯ

แบบสอบถามชุดนี้ได้จัดทำขึ้นเพื่อรวบรวมข้อมูลความคิดเห็นไปประกอบการวิจัยในโครงการวิจัย สกว. เรื่อง “Intelligent Roomware System” ของ อ.ดร.สุรพงษ์ เลิศสิทธิชัย จากคณะสถาปัตยกรรมศาสตร์ มหาวิทยาลัยศิลปากร ซึ่งจะทำการพัฒนาบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ต้นแบบ (Interactive Bulletin Board Prototype) เพื่อนำไปทดลองใช้งานภายในคณะฯ

1. ข้อมูลของท่าน และคณะฯ ของท่าน

ข้อมูลในส่วนนี้จะนำไปใช้ในการวิเคราะห์ผู้ใช้บอร์ดประชาสัมพันธ์ในคณะฯ รวมทั้งข้อมูลเบื้องต้นของคณะฯ ท่าน

ชื่อ ______________________________ นามสกุล ______________________________

* ชื่อคณะฯ ______________________________ * ชื่อวิทยาเขต ______________________________

* อีเมลล์ ______________________________ (*กรุณากรอกข้อมูลที่มี * ให้ครบ*)

1.1 ท่านมีตำแหน่งหน้าที่และบทบาทอะไร ในคณะฯ ของท่าน?

[ ] อาจารย์ (*ภาควิชา:* ______________________)

[ ] นักศึกษา (*ชั้นปีที่:* __________)

[ ] เจ้าหน้าที่ (*ประเภท:* __________)

[ ] อื่นๆ (*โปรดระบุ:* ______________________)

1.2 คณะฯ ของท่านมีวิทยาเขตกี่วิทยาเขต?

[ ] วิทยาเขตเดียว (*โปรดข้ามไปตอบชุดคำถาม 3*)

[ ] มี 2 วิทยาเขต

[ ] มีมากกว่า 2 วิทยาเขต (*จำนวน:* ______ *วิทยาเขต*)

1.3 หากคณะฯ ของท่านมีหลายวิทยาเขต ท่านใช้เวลาอยู่ที่วิทยาเขตใดมากที่สุด?

[ ] วิทยาเขต ______________ มากที่สุด

[ ] ใช้เวลาเท่าๆ กันทุกๆ วิทยาเขต

[ ] ไม่สามารถประเมินได้

1.4 คณะฯ ของท่านมีผู้ที่รับผิดชอบในการจัดการข้อมูลประชาสัมพันธ์ หรือไม่?

[ ] มี ผู้ที่รับผิดชอบคือ อาจารย์ / นักศึกษา / เจ้าหน้าที่

[ ] ไม่มี

[ ] ไม่ทราบ

2. *ข้อมูลเกี่ยวกับบอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน*

ข้อมูลส่วนนี้จะนำไปใช้วิเคราะห์การใช้งานและข้อดีข้อเสียของบอร์ดประชาสัมพันธ์ในคณะฯของท่าน

2.1 ที่คณะฯ ของท่านมีบอร์ดประชาสัมพันธ์หรือไม่?

[ ] มี ประมาณ _____ บอร์ด [ ] ไม่มี (*ข้ามไปตอบชุดคำถาม 3*)

2.2 ท่านเคยอ่านข้อมูลที่ประกาศบนบอร์ดประชาสัมพันธ์ของคณะฯ หรือไม่?

[ ] เคย ประมาณ _____ ครั้งต่อ วัน / สัปดาห์ / เดือน [ ] ไม่เคย

2.3 ท่านเคยนำข่าวสารประชาสัมพันธ์มาติดประกาศที่บอร์ดประชาสัมพันธ์ของคณะฯ หรือไม่?

[ ] เคย ประมาณ _____ ครั้งต่อ วัน / สัปดาห์ / เดือน [ ] ไม่เคย

2.4 บอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน มีติดตั้งอยู่ที่บริเวณใดบ้าง?

1. ______________________________ 5. ______________________________

2. ______________________________ 6. ______________________________

3. ______________________________ 7. ______________________________

4. ______________________________ 8. ______________________________

2.5 ท่านอ่านข่าวสารประชาสัมพันธ์จากบอร์ดประชาสัมพันธ์แห่งใดในข้อ 4 บ่อยที่สุด?

(โปรดระบุ 5 อันดับแรก)

1. ______________________________ 4. ______________________________

2. ______________________________ 5. ______________________________

3. ______________________________

2.6 ข้อมูลประเภทใดที่ท่านพบบ่อยบนบอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน?

(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1--พบบ่อยที่สุด ถึง 5--พบไม่บ่อยนัก)

[ ] ประกาศทั่วไปของอาจารย์ หรือ ส่วนบริหารของคณะฯ หรือมหาวิทยาลัย

[ ] ผลคะแนนการเรียน และการสอบ

[ ] โฆษณา และประกาศทั่วไป (*ขายของ, ของหาย*)

[ ] ประกาศสมัครงาน และว่าจ้าง

[ ] ประกาศทุน และงานประกวดผลงานต่างๆ

[ ] ประกาศทั่วไปของนักศึกษา (*กิจกรรมนักศึกษา, ศึกษานอกสถานที่*)

[ ] อื่นๆ (*โปรดแนะนำ:* ______________________)

2.7 **ข้อมูลประเภทใดที่ท่านอ่านบ่อยบนบอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน?**
(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ประกาศทั่วไปของอาจารย์ หรือ ส่วนบริหารของคณะฯ หรือมหาวิทยาลัย

[ ] ผลคะแนนการเรียน และการสอบ

[ ] โฆษณา และประกาศทั่วไป (*ขายของ, ของหาย*)

[ ] ประกาศสมัครงาน และว่าจ้าง

[ ] ประกาศทุน และงานประกวดผลงานต่างๆ

[ ] ประกาศทั่วไปของนักศึกษา (*กิจกรรมนักศึกษา, ศึกษานอกสถานที่*)

[ ] อื่นๆ (*โปรดแนะนำ:* ___________________________)

2.8 **ท่านคิดว่าองค์ประกอบใดมีความสำคัญต่อลักษณะภายนอกของบอร์ดประชาสัมพันธ์ที่ดี?**
(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ขนาดบอร์ดที่มีความใหญ่โต

[ ] สถานที่ติดตั้งที่เป็นสาธารณะ

[ ] สถานที่ติดตั้งที่มีคนพลุกพล่าน

[ ] ความง่ายในการติดประกาศข่าวประชาสัมพันธ์

[ ] ความคงทนถาวรในการติดประกาศข่าวประชาสัมพันธ์

[ ] ระดับความสูงที่พอดีกับระดับสายตา

[ ] อื่นๆ (*โปรดแนะนำ:* ___________________________)

2.9 **ท่านคิดว่าองค์ประกอบใด ที่ทำให้ข้อมูลบนบอร์ดมีความน่าสนใจ?**
(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ใช้กราฟฟิค และองค์ประกอบที่เรียบง่าย

[ ] ใช้สีสันที่สวยงาม และสะดุดตา

[ ] ใช้ตัวหนังสือที่มีขนาดใหญ่ สามารถมองเห็นได้แต่ไกล

[ ] ข้อมูลที่มีความถูกต้องแม่นยำ มาจากแหล่งข้อมูลที่มีความน่าเชื่อถือสูง

[ ] ข้อมูลที่มาจากหลายๆ หน่วยงานหรือหลายๆ วิทยาเขต

[ ] ข้อมูลที่ใหม่และทันเหตุการณ์

[ ] อื่นๆ (*โปรดแนะนำ:* ___________________________)

2.10 ท่านได้รับทราบข้อมูลข่าวสารจากคณะฯ หรือหน่วยงานอื่นๆ จากการอ่านบอร์ดประชาสัมพันธ์ในคณะฯ ของท่านเป็นประจำ?

[ ] เห็นด้วยมากที่สุด [ ] เห็นด้วยน้อย

[ ] เห็นด้วยมาก [ ] ไม่เห็นด้วย

2.11ท่านได้มีการติดต่อแลกเปลี่ยนข่าวสารและข้อมูลประชาสัมพันธ์กับนักศึกษาหรืออาจารย์ ที่อยู่ต่างวิทยาเขตกับท่านหรือไม่?

[ ] มี โดยประมาณ _____ ครั้งต่อ วัน / สัปดาห์ / เดือน [ ] ไม่มี

3. ความคิดเห็นเกี่ยวกับโครงการวิจัยบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ต้นแบบ

ข้อมูลในส่วนนี้จะนำไปใช้เป็นแนวทางในการออกแบบบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ต้นแบบ (Interactive Bulletin Board Prototype) ให้กับคณะฯ ซึ่งบอร์ดดังกล่าวจะประกอบไปด้วยจอ LCD ขนาด 42 นิ้วและเนื้อหาข้อมูลแบบอิเล็กทรอนิกส์ที่มีการฉายหมุนเวียนบนจอ โดยผู้ใช้สามารถโต้ตอบกับข้อมูลบนจอ และผู้ใช้คนอื่นๆ ได้

3.1 ท่านคิดว่าบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ที่จะนำเสนอในงานวิจัยดังกล่าวควรจะมีลักษณะเหมือนหรือแตกต่างจากบอร์ดประชาสัมพันธ์ในคณะฯ ของท่านอย่างไร?

[ ] เหมือน ____________________

____

____

____

[ ] ต่าง ____________________

____

____

____

3.2 คุณสมบัติ (Features) ใดที่ท่านอยากให้มีในบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์?

(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ประกาศข่าวต่างๆ

[ ] ประกาศทุน / สมัครงาน

[ ] แจ้งข่าวเกี่ยวกับนิทรรศการต่างๆ

[ ] แบบสอบถาม / โพลล์ / และการลงคะแนนเสียง

[ ] Web camera ถ่ายทอดสด

[ ] ส่วนสำหรับแสดงผลงานนักศึกษา หรือ ผลงานวิจัย

[ ] บอร์ดสามารถโต้ตอบกับผู้ใช้งานได้

[ ] สามารถส่ง Forward email เพื่อกระจายข่าวได้

[ ] อื่นๆ *(โปรดแนะนำ:* ____________________)

3.3 หากคุณสมบัติที่ต้องการจากข้อ 2 อยู่ในการพิจารณาขณะทำการออกแบบ และได้มีขึ้นอยู่ในบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ ท่านจะใช้งานและอ่านข้อมูลในบอร์ดต้นแบบนี้หรือไม่?

[ ] ใช้งานบ่อย

[ ] อาจใช้ บางครั้ง

[ ] ไม่ใช้งานเลย

3.4 ท่านคิดว่า บอร์ดประชาสัมพันธ์ที่มีคุณสมบัติในการโต้ตอบกับผู้ใช้ได้ จะทำให้มีการแลกเปลี่ยนข้อมูลและช่วยเสริมสร้างความสัมพันธ์ที่ดีระหว่างนักศึกษา อาจารย์ และเจ้าหน้าที่ให้มากขึ้นได้?

[ ] เห็นด้วยมากที่สุด

[ ] เห็นด้วยมาก

[ ] เห็นด้วยน้อย

[ ] ไม่เห็นด้วย

ขอขอบคุณทุกท่านที่ให้ความร่วมมือในการตอบแบบสอบถามชุดนี้
หากตอบแบบสอบถามเสร็จแล้วขอความกรุณาช่วยส่งคืนมาที่ ____________________ ก่อนวันที่
________________ขอบคุณครับ/ค่ะ - คณะผู้วิจัย

2. INTERNATIONAL PUBLICATIONS

2.1 Back, M., Lertsithichai, S., Chiu, P., Boreczky, J., Foote, J., Kimber, D., Liu, Q. and Matsumoto, T. (2008). *Rethinking the Podium*, in Dillenbourg, P., Huang, J., and Cherubini, M. (Eds.) *Interactive Artifacts and Furniture Supporting Collaborative Work and Learning*. Springer 2008, pp. 97-110.

2.2 Khampanya, R. and Lertsithichai, L. (2009). *TangiDESK: A Tangible Interface Prototype for Urban Design and Planning*. CAADRIA 2009 Full Paper.

Rethinking the Podium: A Rich Media Control Station for Next Generation Conference Rooms

Maribeth Back, Surapong Lertsithichai*, Patrick Chiu, John Boreczky, Jonathan Foote, Don Kimber, Qiong Liu, Takashi Matsumoto, Frank Zhao

FX Palo Alto Laboratory
3400 Hillview Avenue, Bldg. 4
Palo Alto, CA 94304, USA
{*lastname*}@fxpal.com

*Silpakorn University
Faculty of Architecture
Bangkok, Thailand
surapong@post.harvard.edu

Abstract. As the use of rich media in mobile devices and smart environments becomes more sophisticated, so must the design of the everyday objects used as containers or controllers. Rather than simply tucking electronics into existing forms, an original design for a smart artefact can enhance existing use patterns in unexpected ways. The Convertible Podium is an experiment in the design of a smart artefact with complex integrated systems. It combines the highly designed look and feel of a modern lectern with systems that allow it to serve as a central control station for rich media manipulation in next-generation conference rooms. It enables easy control of multiple screens, multiple media sources (including mobile devices) and multiple distribution channels. The Podium is designed to support in a flexible manner the various interaction tasks that are dependent on the social context of the meeting, from authoring and presenting in a rich media meeting room to supporting remote telepresence and integration with mobile devices.

1 Introduction

Next generation meeting rooms are designed to anticipate the onslaught of rich media presentation and ideation systems. Even today, high-end room systems feature a multiplicity of display screens, smart whiteboards, robotic cameras, and smart remote conferencing systems, all intended to support heterogeneous data and document types. Exploiting the capabilities of such a room, however, is a daunting task. Faced with three or more screens, all but a few presenters opt for simply replicating the same image on all of them.

At the same time, creating engaging meeting experiences can improve communication, facilitate information exchange, and increase knowledge retention. The incorporation of media-rich engagement strategies in meetings creates a need to provide the presenter with appropriate tools for managing these media.

The Convertible Podium is a central control station for rich media manipulation, including multi-screen multimedia presentation, shared annotation, and digital multimedia support for teleconferencing. Designed for intelligent meeting support and capture, it is an intuitive, easily operated way station for directing digital information. It is a valuable tool that can allow presenters to easily create and integrate rich media experiences into their work. It is also an experiment in integrating physical design and form with rich media functionality.

(A) **(B)** **(C)**

Fig. 1. Design sketch: a convertible podium converting from a media-screen podium (A), to a capturing device (B), to an upright mode that can be used for an avatar representation of a remote presenter, an interactive whiteboard, or an information board (C)

Unlike conventional podiums, the Convertible Podium is a compact, lightweight, mobile design that can provide multiple functionalities by converting its form. It converts from an interactive rich media presentation podium to other functions useful in a conference room environment, including capturing devices, an avatar representation for a remote presenter, an interactive whiteboard, and an information board. An important design imperative is that all devices are integrated into the frame structure of the podium. Some devices are assigned multiple functionalities, depending on what interaction mode is active. However, only one mode of interaction is possible at each conversion. Similar to multi-purpose furniture or “Roomware" [24], the Convertible Podium combines its affordances as a regular podium with the capabilities of other presentation devices while maintaining its primary form and usefulness as a podium.

The Podium provides a focal point for the attention of the meeting and directs information in as many directions as required—both locally and remotely. It allows one person to manage multiple documents and streams of information directed to or from the conference room, or to multiple displays within the room. The Podium also controls the room environment: lights, sound, and projector controls. More than just a presentation device, the Convertible Podium facilitates rich media authoring, data and image capture, and interactive communications. One person can easily and rapidly convert the system between its active modes.

Interacting with the Convertible Podium can be done in three physical modes (Figure 1). In the interactive podium mode, a local presenter can use this podium to make presentations using multiple screens in a random-access fashion, simply using the familiar drag-and-drop technique to project anything, in any order, from a pool of slides or other media. Of course it is also possible to present media in the more familiar linear fashion, just as one presents PowerPoint slides on a single screen. Or, a presenter can switch between these modes, choosing random access to slides at times, and using pre-scripted linear segments at other times [14].

When the Podium's hood is lifted halfway, it goes into "Capture" mode, allowing the capture of documents and images via scanner and camera. A scanner which lies under the LCD monitor is exposed and is used via the "second screen": a small-form networked computer [20]. The presenter can also use the exposed document cameras for live demos or for showing off objects during a presentation.

In the third mode, "Avatar/Telepresence," the Podium's hood is fully upright. In this mode, it can be connected to a remote avatar for teleconferencing, or converted to an interactive whiteboard or an information board for supporting different presentation activities in the room. As an avatar appearing on the upright LCD screen, a remote presenter can access the Podium from a remote desktop, a laptop, or another Convertible Podium. The multiple room displays and the room speakers can output live video and audio from the remote presenter.

For example, during a discussion, the display can be used as an interactive whiteboard to capture annotations and notes contributed by participants in the room. If the Podium is not actively in use, it can also be placed in front of a room and used as an information board to display a room calendar, or other kinds of asynchronous messages, similar to a bulletin board. Details of the functions within each mode are listed more fully below.

2 Context: rethinking the conference room

The Convertible Podium project is informed by contextual inquiry into the implications of rich media for the kinds of work conducted in meeting rooms and lecture halls. It is designed to integrate with continuing research in multimedia, education, collaborative work and knowledge sharing systems. As new technologies like e-paper (electronic paper) make displays even more ubiquitous, the challenge becomes the management of rich media content across a number of screens. Added into the mix are meeting participants and the devices they carry with them: laptops, cell phones, and PDAs.

Fig. 2. Two top-down views of designs for a rich media conference room, showing a variety of options for multiple wall-mounted displays, varied seating to encourage informal as well as formal meetings, and embedded interfaces as well as connectivity for mobile devices.

Opening up a meeting room's media systems to support distributed collaboration raises yet another set of presentation and display issues. We are interested in analyzing and supporting not only the room systems, but also the process of work that happens there. For example:

- How should the room support presenters and participants during a variety of situations, including formal and casual meetings, discussions, and presentations?
- What capture technologies and media database functions are appropriate, and how do they support ongoing collaborations?
- How can both presenters and meeting participants interact with multiple-screen, multimedia, remote presentations?
- What are the implications of new technologies like e-paper as well as current technologies like RFID, cell phones, PDAs, and other multi-function devices?

Fig. 3: Two design views of a rich media meeting room: integrating multiple modalities (audio and visual), wall-sized screens, encouraging formal and informal interchange, and creating channels for shared input from meeting participants via portable devices

2.1 Function follows form: interactive furniture for meeting rooms

Lightweight, mobile, and transparent, the Podium's deliberately sleek aluminum form references tools or equipment as well as furniture. As such, it encourages hands-on participation and control. Our approach to the design of the Convertible Podium has its roots in Mark Weiser's ubiquitous computing [26] and Hiroshi Ishii's tangible media [9]. Weiser's vision of widely distributed, networked devices permeating our living and working spaces has begun to be realized with the advent of cell phones, PDAs, and smart furniture. At the same time, Ishii's research into the affordances of tangible controls for complex software systems has driven the work of many research designers. Tangible devices and ubiquitous computing are a natural match; Fishkin [6] has created a taxonomy detailing research in this area. A number of researchers have combined these two ideas in the context of devices for reading, writing, and document management e.g. [3, 18, 21], which map well to frequent meeting tasks.

Fig. 4. The Convertible Podium's first operational prototype is CNC-machined from aluminum and acrylic panels and incorporates an onboard computer, WiFi, RFID, and custom sensing electronics.

Researchers at labs such as the MIT Media Lab and the Aware Home project at Georgia Tech (and there are many others) have built smart networked objects, including interactive furniture, for home, personal and business environments [11, 19]. A major criterion in this podium design is a form factor that is both elegant and functional. We also wanted to create an article of smart furniture with physical dynamics – that changed its physical shape as well as digital content. This is a "transformer" metaphor, where current functionality is mapped to the physical state of the object: function follows form.

2.2 Related work

Early versions of the electronic conference room focused on television and telecommunications technologies to support remote collaboration or to capture an electronic record of meetings. Today's media technologies for the meeting room are generally digitally integrated and often serve a variety of ends: multimedia presentation, meeting capture, note taking, informal design sessions, discussion group support, and Web use, as well as traditional live lectures. A huge amount of research has been undertaken in this area, e.g. [1, 10, 15, 17, 24], along with work done at our lab [4, 5, 7, 13, 27]. In the Podium project, we make an effort to fold much of this technology into the Podium itself, streamlining both the communication methods and the control systems for them. Many current podiums are ad hoc repositories for such centralization, with bits of technology added on; we are designing it in deliberately.

Commercial podiums on the market are mostly podium enclosures designed to accommodate a variety of equipment that is used to facilitate different presentation needs in a classroom or lecture hall. A typical podium designed for a multimedia room is equipped with devices ranging from large devices such as a PC, a display, or a document camera to small add-on devices such as light visors, microphones, or an A/V switching device. Each stand-alone device has a specific function and requires a dedicated space for installation. Packaging all these devices into a single podium requires a bulky and heavy enclosure with several tethered (or many untethered) cables, making it difficult to move the podium from one room to another, or even to a different spot in the same room.

Since this combination of the convertible design and functionalities is unique, there is no other podium available that incorporates these features or is similar in implementation. However, there are a few systems that are similar in part.

Teleportec has a product called the Teleportec lectern [25] which is a podium with a reflective screen similar to a teleprompter's set up. It uses a monitor that lies flat at the podium base to display video of a remote presenter and a large 30"x 40" transparent projection surface angled at 45˚ facing the front of the podium to reflect the display on the base. Using reverse chroma key, the background is removed and the presenter appears visible behind the podium. However the Teleportec lectern has no user interactivity and cannot be used by a remote presenter. It is a fixed set up that requires a backdrop wall to hide a videoconferencing camera behind the podium and in some cases a canopy to avoid direct light on the glass surface. The image of the remote presenter on the reflective screen may not be fully visible at extreme corner viewing angles. Because of its fixed setup, it is not portable and cannot be easily moved from one room to another.

Smart Technologies Inc. has a product called Sympodium [22] which comes in four variations; an interactive lectern, a tabletop lectern, and two integration modules. The Sympodium interactive lectern is equipped with a touch sensitive LCD display that allows users to annotate over documents and control applications from a connected internal PC, laptop, or document camera. The desktop image is displayed through an external projector or large presentation screen allowing audiences to view annotations from the presenter's display. Sympodium has only three video source inputs which can be manually switched by the user. It cannot integrate more input and output devices and cannot control presentation devices or environmental settings.

ETH – Zürich has produced a prototype interactive podium called the "SpeakersCorner"[12] designed to facilitate local and remote teaching. This system is a customized podium enclosure equipped with a touch screen LCD display, a document camera, a dual-processor PC, a fold away keyboard, and an integrated connecter with USB, video, and network connections. It provides a multimedia platform for a presenter to show his/her slide presentation while making real time annotations on the slides. However, each input device implemented here is a stand alone device, designed for a specific application. They are placed in separated parts of the podium and cannot be used for multiple applications.

3 Rich media and active meeting participation

Rich media is usually understood to mean a combination of static and dynamic images and text, including video and multimedia documents available locally or via the internet. As displays become larger and more ubiquitous, the uses and designs of rich media will also change. How can we comfortably control, for example, three parallel video streams, along with presentation slides and a live remote presenter? What kind of content maps well into such a rich environment? How do local participants interact with the information they see projected around them, and how do remote participants interact with the same information?

Active meeting components such as presentation, discussion, small group work sessions, debate, and problem solving can all be enriched by thoughtful use of multimedia components. Whether on-site, remote, or asynchronous meeting situations, the cluster of information applications in the Podium can enable or improve these common tasks and interactions:

- Participant interactions with leader and with each other via online text, in-room backchat, and sending text or images from mobile devices like cells and PDAs
- In-sequence presentations, especially a quick series of them (six or seven people each presenting a five-to-seven minute talk, for example)
- Drawing onscreen (live whiteboard, capture to web instantly)
- Multiple side-by-side comparison views -- not just two-way as with most slide projector setups
- Guest lecturers via remote viewing – avatar mode plus rich media presentations
- Printing and paperwork including JIT printing
- Document camera for demos or quick capture for images from workgroup sessions

Fig. 5. The Convertible Podium's operational prototype upright in preparation for avatar mode. A motorized counterbalance system is installed within the aluminum strut along the left side of the Podium's faceplate, to handle the weight of the LCD monitor and its aluminum framing. In later designs, the monitor will be replaced with thinner lightweight displays such as e-paper or OLEDs

4 Operation: functionality follows the form of the device

One person easily accesses and controls complex functionality through simple physical manipulation. As the counter-weighted hood swings open, the Podium switches modes and applications, from presentation, to capture, to remote conferencing or networked whiteboard. The tangible interface offers centralized control over both room and computer systems.

4.1 Mode 1: Rich media presentation

The Podium uses ePic, a rich media presentation application especially developed to handle multiple screens, as one of its primary presentation mode for showing slides, Web, video or other media [14] Live annotation is available via touch screen (using finger or pen). Any image can be transferred to any screen with a flick of the finger across the touch screen; alternatively a sequence of slides and media can be pre-programmed to execute across any number of screens, in any order. Speakers are also individually addressable for audio output.

Because the monitor screen shows not only control systems but also the content of the screens themselves, a presenter does not need to turn away from the audience, toward the screen, to read what's on his or her own slide. This, though simple, is one of the single biggest affordances of the Podium: allowing a presenter to keep facing the audience, rather than turning from them.

Fig. 6. An early example of a user interface: ePic multi-screen remote presentation

4.2 Mode 2: Image and data capture

As the hood of the Podium hinges into the half-way open position, the Capture Mode becomes available. Digital images and real-time video demos are captured via onboard scanner and a document camera (Figure 7). A visor light provides needed light levels. Image capture is controlled via a small secondary computer (originally we planned to use a PDA, but we have decided instead to use a small-form-factor Windows XP computer, made by OQO [20]). Images can be directed to room screens, to nearby or remote printers, or filed in a meeting media database.

As the LCD screen flips upwards, a document or object placing area is revealed beneath the screen, along with a thin scanner. Beneath the screen is a light visor to highlight the area. A hi-resolution digital camera is centered at the top edge of the screen. In this mode, the camera is used as a document camera to take snapshots of a document or to stream video of an object demo.

- Scanner for on-the-spot document capture
- Document camera with visor lighting
- Small screen computer for capture systems
- JIT (just in time) printing

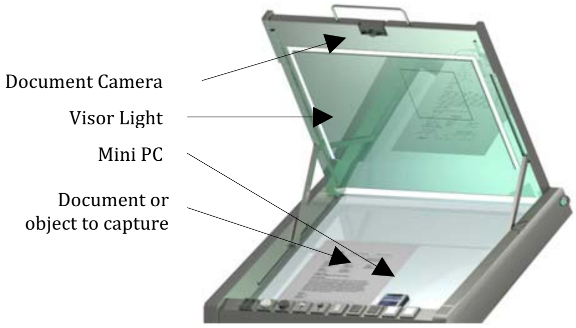


Fig. 7. Design sketch: during capture mode, the high-resolution digital camera becomes a document camera for capturing documents or physical objects

4.3 Modes 3, 4: Avatar / interactive whiteboard

Avatar/telepresence mode supports human-scale video avatars for teleconferencing. In an effort to enliven the static talking-head video image most people associate with videoconferencing, the Podium's Avatar/telepresence mode features a life-sized, center-screen image of a remote presenter's face. The image appears on the Podium's LCD screen when it is fully upright, appearing there at approximately human head height. The facial image can also appear on one of the room screens if desired. Remote presenters can control rich media multi-screen presentations from their remote locations, and interact with meeting participants via high-quality video and audio streaming.

Networked interactive whiteboard and interactive annotation systems enable local or long-distance group work such as planning, brainstorming and discussion.

- Teleconferencing and remote presentation via existing systems
- Or via experimental high bandwidth video streaming
- Networked drawing/slide annotation system
- Automatic meeting capture and retrieval

4.4 Post-laptop design (backwards compatible)

Though the Podium is deliberately designed as a post-laptop device, it of course allows the connection of many kinds of external devices including laptops, PDAs, cell phones, and portable USB/FireWire drives. Or, through the use of a network application using RFID cards [8] one's personal files can be securely uploaded from any networked computer on the LAN.

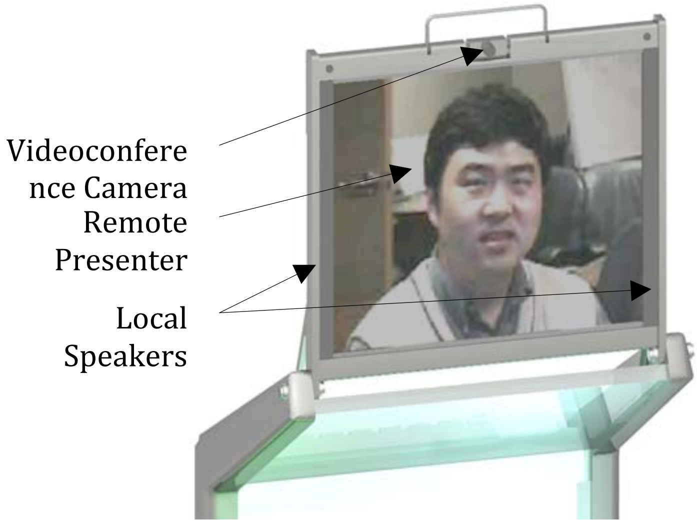


Fig. 8. Design sketch: Avatar mode.

5 Physical design and technology

The Convertible Podium is human-scale, lightweight, mobile, a clean, simple, powerful control center. Intended to avoid tangles of cabling, its mobile design allows the front of the room to be a flexible space. It is easily wheeled aside to allow different configurations according to group needs.

- **Aluminum and acrylic** are the basic building materials, plus built-in custom electronics: tangible control strip, LCD monitor/touchscreen, LEDS for mode indication and a visor light for the document cameras.

- **An acrylic panel** (a 24'x 38.6" vertical support bent to a 24"x 20" lectern surface that is 31.6° from horizontal) is outlined and supported by **one-piece aluminum/alodine-finish side supports**. The body of the podium consists of an acrylic panel shaped like a slightly angled upside down letter "L." The panel can be sidelit with LEDs (colored according to mode) and the control panel can be etched with the company logo. Along both sides of the panel are two aluminum frames that are the main structure of the podium and hold the entire body together. These side supports are also used as conduits for internal wiring and cables as well as a holder for wireless network antenna.

- The desktop surface area is a **touchscreen LCD display** measuring 24" diagonally. At the bottom edge of the display between the two side frames is a tray that holds the control electronics. The control unit is a strip holding physical controls such as dials, switches, and sliders that are used as physical controls mapped to certain functions or commands in the application currently in use. Beneath the controller tray is space for external connection jacks: USB, audio, and FireWire.

- The **wheeled base** (also aluminum/alodine) is a modified x-shape with an **underslung tray** that holds the **electronics** (laptop computer, AC power, A/D control card, USB hub and various USB remotes, network connections.)

- **Modal functionality** is cued from position of the **swing-open hood**: Presentation, Capture, Telepresence/Avatar or WhiteBoard.

Fig. 9. The control strip features large, tangibly pleasing buttons and knobs that map clearly to software and environment controls. The control modules are modular and can be custom-designed for use with specific installations. In this case, software controls appear on the right; room controls are on the left

5.1 Programmable tangible control strip

The Podium consolidates environmental and multimedia controls at one easy-access point. A custom analog/digital hardware module, combined with the touch screen, offers control of many common meeting room tasks: screen/projector settings, room lighting, audio volume, presentation and annotation software, and remote teleconferencing.

- Control strip hinges open for easy access to electronics
- Modular plug-n-play design: controls are configurable in software.
- Custom modules can be CNC-machined to meeting changing specifications or to suit a new client.

5.2 Custom electronics and software

Custom software (one version written in MAX/MSP, and another in C++) and A/D hardware control systems drive the Convertible Podium's services. The Podium's onboard laptop "brain" networks with a number of exterior systems. For sound, projection, and light control in the room, it communicates via an http/python middleware protocol [6] with a standard AMX environmental control system. [1]

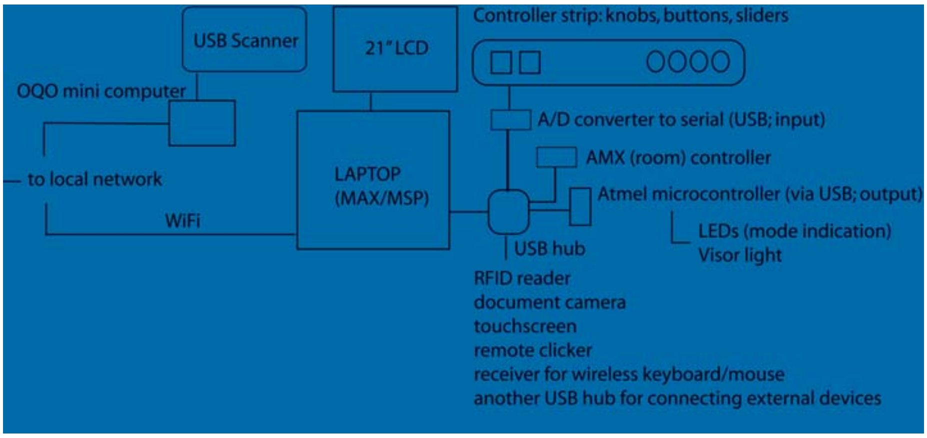


Fig. 10. Inside the Podium: system sketch

For teleconferencing and remote presentation, meeting capture, media control, and document sharing, we use the same protocol to communicate with a suite of applications developed in our lab. One application was developed for authoring and presenting on multiple screens and speakers, both locally and remotely. [27] Another, PIP (Personal Interaction Points), allows a person to simply swipe an RFID card across a reader to automatically open a directory listing all her Powerpoint files on her own machine (as long as it's on the same local area network). [8] When RFID chips become more common in cell phones (as the FeliCa RFID chip already is in Japan), that means that a presenter could use a simple swipe of her cell phone as an identifier to open the Podium's systems and upload a presentation automatically.

Fig. 11. Above right, the right arm strut on the mill bed.

5.3 CNC-machined parts, custom modules

We deliberately chose computer-controlled machining as a primary element in the build process, to provide modular adaptability to a particular client's needs (for example, an etched logo on the front of the control strip, or an extended set of controls for a more complex lighting setup). Most major Podium parts were computer milled (CNC, or computer numerical control, is a standard machining procedure) from aluminum, allowing a slim-line curved design with enough hollow space for the electronics and cabling. The relatively large number of onboard devices meant lots of room was needed for cabling – not only for the signal cables, but for power as well.

Fig. 12. The control strip and LCD screen installed, on the left; the control strip without buttons, the base and the side struts partially assembled, right.

6 Next steps

Though much of the rich media authoring and control software that supports it has been under development for years, we have just completed the first operational physical prototype of the Convertible Podium. Before moving on to the next stage of design, we will do several usage studies, on each mode's software and on the physical aspects of the device. Results from these studies will certainly impact the next stages of the design and may result in modifications to this first prototype as well.

We also intend to create a suite of lightweight podium variants, including specialized applications for mobile devices, for meeting rooms, classrooms, seminar rooms, and tabletops. Each can be fine-tuned for a particular context or environment. As displays and electronics become increasingly thinner and lighter, we expect to see improved mobility and flexibility in the design.

We intend more work on the integration of *n*- mobile devices into an electronic conversation or discussion, particularly cell phones. In addition we intend to make the physical frame of the Podium even more flexible, adding motorized height and angle adjustability. Companion objects such as e-paper media screens or tabletops, smart whiteboards, and other smart-room components may be integrated into the next iteration of the Convertible Podium system.

Finally, we found that for smart furniture, interesting things happen when *function follows form,* especially in conjunction with tangible controls and rich media. This heuristic has led us to a rich design space that we intend to continue to explore.

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TANGIDESK: A TANGIBLE INTERFACE PROTOTYPE FOR URBAN DESIGN AND PLANNING

ROM KHAMPANYA
Faculty of Architecture and Planning, Thammasat University
romkoolhaas@gmail.com

AND

SURAPONG LERTSITHICHAI
Faculty of Architecture, Silpakorn University
surapong@post.harvard.edu

Abstract. This paper describes the design and implementation of TangiDESK, a tangible interface prototype to assist in the design and planning of urban design projects. The prototype derives from the need for an intuitive user interface similar to a designer's or architect's CAD system but also simple enough for non-designers like city planners and developers who are not accustomed to CAD interfaces to use and understand easily. TangiDESK displays a plan view of an urban project on its top surface while physical objects placed on the surface by users represent urban elements such as buildings, roads, parks, or landmarks to form a three-dimensional representation of the site. Objects placed here by any user will be detected by the system and additional information about the object is projected in real-time for users to view its general properties and construction costs. Users can manipulate the objects or modify its relationship with other elements in the site while making preliminary design decisions together in a single environment. With TangiDESK, designers and planners can collaborate and make informative decisions more effectively and accurately in early stages of an urban design project.

Keywords. Tangible User Interface; Urban Design and Planning; Computer-Aided Design; Collaborative Design; Project Feasibility.

1. Introduction

During the early design phases of any urban construction project, specifically in schematic planning, the main task of the design team (architect, engineer, interior designer, etc.) is to gather as much project requirements as possible from the development team (owner, planner, advisor, etc.) and devise working schematic designs that can be studied further for project feasibilities in later phases of the design process (Wuthikosithi, 2003). These schematic designs can be presented in various formats or produced in many types of medium in which are determined by what is considered the most effective communication method between both the design and development teams.

For the design team, the most common communication method is to use two-dimensional drawings produced by Computer-Aided Design systems (CAD) to convey design information by means of representing three-dimensional buildings and surrounding elements (road, pool, landscape, infrastructure, etc.) and depict their relationship in the project site. On the other hand, the development team communicate their planning information regarding costs, schedule, management hierarchy, and feasibility studies in forms of tables and diagrams generated by spreadsheet software that may or may not be easily transferred into designs and drawings.

In both cases, it may be difficult for each team to easily comprehend each other's information due to the fact that their information may be incoherent or are typically viewed in separate working environments. Also, the level of expertise and experience in the use of tools and of their analytical thinking are very different and are not effectively integrated in one seamless medium or environment.

2. Related Work

The problem of information transfer between the design and development teams may result it certain delays of decision-making efforts agreed by both teams and eventually the lack in feasibility of the schematic design. In past years, there have been several attempts to eliminate this problem by integrating familiar analog techniques with efficient digital environments that allow designers to interact with digital information seamlessly and intuitively during early design processes. Some of these include Tangible User Interfaces (TUI) for urban design (Ullmer and Ishii, 1997; Underkoffler and Ishii, 1999), Augmented Reality systems (AR) for urban planners (Billinghurst and Kato, 1999; Buchmann et al., 2004) and 3D simulations for feasibility studies (Freeman and Steed, 2006; Keawlai, 2007; Fisher and Flohr, 2008).

MetaDESK and Urp are TUIs that have urban design and planning applications developed for designers who need to collaborate with many parties simultaneously in a single environment. However, the main purpose is to view existing designs and not to assist designers in making informative design decisions along with city planners and urban designers.

FingARtips is an AR project that requires users to wear heads-up displays or virtual glasses to be able to view digital information that is overlaid onto physical objects in the real world. However, this feature is limited by the amount of concurrent users the system can handle at a given time and the cost of equipment per user may not be feasible for many participants.

This paper intends to explore new applications with TUI technologies by assisting design decision-making tasks that designers and developers face together during the early stages of schematic design in an urban design project. The proposed system consists of a tangible user interface as its primary means of user input and a semi-intelligent system to interpret user interactions that provides useful information to users in real-time in order for them to make better-informed design decisions.

3. Early Design Phase in Urban Design and Planning

During the schematic design phase of an urban design and planning project, the main participants of this phase are architects, owners, city planners, real estate developers, and financial analysts who contribute their specific expertise to make collective decisions for the project (Wuthikosithi, 2003). Some of these tasks include planning building zones, infrastructure, public common spaces, green area, and number of buildings. Also, they need to consider the design in conjunction with local building codes and estimate construction costs in order to conclude the project feasibility study.

It is during these tasks that both designers and developers need to exchange information back and forth in a linear fashion until a final compromise is met leading towards an agreeable and effective design. However, due to the problem of incompatible work environments of both teams, information cannot be easily transferred or modified simultaneously by both teams to compact the time spent in this phase. The ideal solution for this problem is to have an integrated environment for both designers and developers to use concurrently and be able to manipulate, modify, or make changes to either the design or the building information with great ease. As such, many decisions that need input by each party can be resolved at the spot and changes in the design can then be updated instantly.

In summary, we have concluded that the four main issues that have the most impact in the decision-making conducted during the project feasibility study are building types, building area, building codes, and cost estimation. As for the ideal interface for the system, it must be flexible and intuitive for both designers and developers to use together with applications for both parties to utilize in a single environment.

4. Design Tool for Urban Design and Planning

In order to prove our conclusion about the ideal tool for urban design and planning, we plan to build a system that takes into account the four project feasibility issues identified earlier and the interface design that incorporates an integrated work environment for both designers and developers.

4.1. APPLICATION FRAMEWORK

The main application of this system lies in the interpretation of user feedback and providing the user with both an intuitive interface and instant feedback of relevant results. The process starts from the user interacting with the physical objects as if he would do so with an actual physical model of an urban project. Information is then calculated on the fly and results are projected immediately in the corresponding location where the physical object is located on the tabletop (Figure 1).

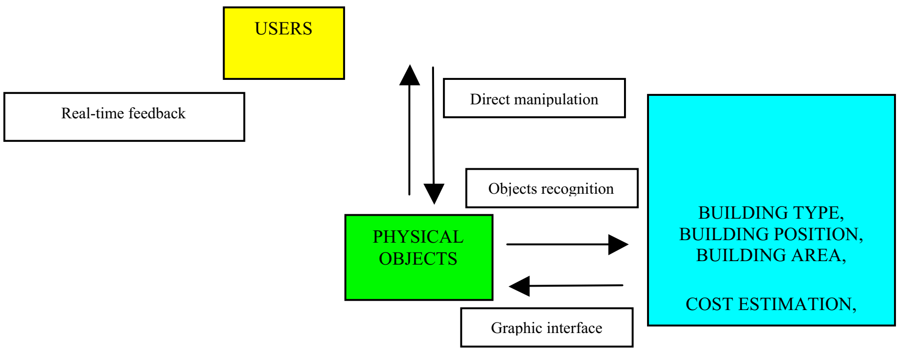


Figure 1. The System Application Framework.

Users can reiterate the process of manipulating objects, adding or removing objects until both designers and developers have agreed upon a satisfactory design. The system can then output the building types, positions, basic properties, and costs into a working drawing for further detail developments.

4.2. SYSTEM COMPONENTS

The system is comprised of four main components: the Tangible interface, the Object recognition component, the Graphic presentation component, and the Database component (Figure 2). Users will interact with the system from a tabletop surface while all computations and feedback will be provided from beneath the table surface.

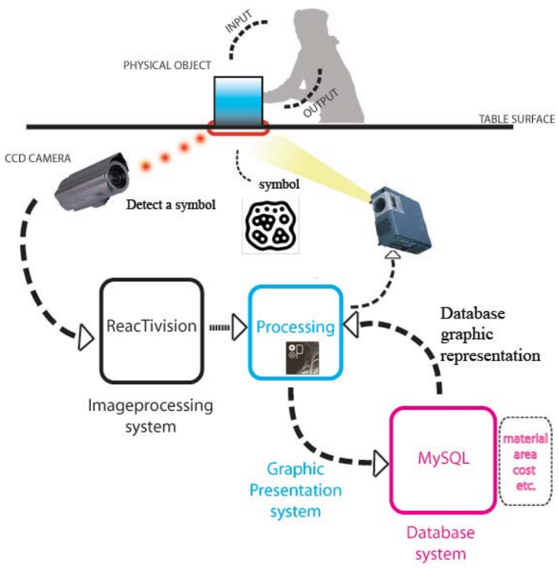


Figure 2. Overall Components and Process Diagram.

4.2.1. Tangible Interface

Tangible user interfaces (Ishii and Ullmer, 1997; Kim and Maher, 2006) are intuitive interfaces used to couple physical objects with digital information by means of physical input from its users. For this system, the tangible interface is the most crucial component for the user since it represents both information and manipulations to physical objects. The tabletop is also important for completing design tasks such as moving and removing objects that is most familiar in design tasks of designers and developers.

With the tangible interface, the input and output sources are integrated in the system. The CCD digital camera as means of input is attached to the bottom of the table. The projector as means for output is used to project information by overlaying it beneath the physical object. Whenever a marker is moved, rotated, or removed altogether, the camera will detect all changes, make calculations, then project the results onto the current marker wherever it is in its present location.

4.2.2. Object Recognition Component

There are many object recognition systems that are widely available for public use such as ARToolKit (Kato and Billinghurst, 1999) which is a software library for building Augmented Reality applications and reacTIVision (Kaltenbrunner and Bencina, 2007) which is an application framework designed for developing table-based tangible user interfaces. Both systems allow users to download and develop specific applications around the framework that utilize optical cameras to track physical markers in the real world.

We have explored both systems and designated reacTIVision as the main object recognition system due to its robust processing capabilities and flexibility in integrating popular programming environments i.e., Processing and Pure Data. reacTIVision works by acquiring images from a CCD camera and searches the video stream frame by frame for specific fiducial symbols or markers that are attached underneath a physical object (building object). Once a fiducial symbol is identified, it is matched to a library of unique fiducial ID numbers and its corresponding data in which can then be displayed or projected as user feedback (Figure 3).

Figure 3. reacTIVision fiducial ID recognition diagram.

reacTIVision includes several unique fiducial symbols with its system for users to attach to a single object or multiple objects according to the users' main application. The fiducial tracking algorithm is also highly efficient due to its well-designed marker geometry. This allows the system to minimize the size of its fiducial symbols, speed up its recognition process, and enable the system to handle the tracking of many fiducial symbols concurrently.

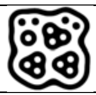
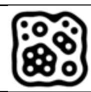
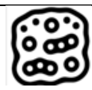
4.2.3. Graphic Presentation Component

Once a fiducial ID has been retrieved, the system will need to generate the graphic representation to be displayed on screen or on the tabletop. This representation is generated by Processing (www.processing.org: Aug 2008) which is an open source programming language and environment working in conjunction with reacTIVision. When a fiducial ID has been detected, Processing will retrieve the ID number and find a match in an existing database in order to execute further commands such as calculating cost estimations or generating graphic images to be displayed back to the reacTIVision enabled tabletop.

4.2.4. Database Component

Currently, the database is developed with MySQL for ease of use and its scalable database. Most importantly, Processing can interface directly with MySQL to obtain data such as building types, building area, construction cost, etc. that is embedded within each fiducial ID or physical object on the tabletop (Table 1). The database component can also be updated when more fiducial IDs or new building objects are introduced into the system. A wider range or general properties can also be added if further analytical tasks are needed for complex calculations as well.

TABLE 1. Database of the fiducial symbols used in the system.

Fiducial Symbol				
Fiducial ID	Fiducial_ID_1	Fiducial_ID_2	Fiducial_ID_3	Fiducial_ID_4
Building Type	House 1	House II	Garden	Pool
Cost per Sqm.	฿8,973	฿10,356	฿100	฿10,000
Total Area	200 sqm.	300 sqm.	2500 sqm.	400 sqm.
Coordinates (x, y)	70m, 20m	100m, 20m 130m, 20m 160m, 20m	100m, 25m	150m, 25m
Amount	1	3	1	1
Construction Cost	฿1,794,600	฿9,320,400	฿250,000	฿4,000,000

5. TangiDESK Prototype Design and Implementation

From our many observations in urban design projects, we think that the best and widely accepted means of design and planning a project should be a collaborative effort between designers and developers. All main decision makers must be present to gather around a large tabletop surface covered with models and large master plans. Changes and modifications to the models or drawings should be recorded, documented, and distributed among the participants for later reference.

From this observation, we decided to tackle the problem of information transfer between project team participants that occur at these tabletops and utilize a tangible user interface system to integrate design elements with spreadsheet data. The prototype system was named "TangiDESK" to describe the properties of where the collaboration effort occurs and how it is handled. Then a real-life project is carefully chosen to obtain real data and scenarios. The TangiDESK system is then designed and implemented around the required collaborative design tasks.

5.1. PROTOTYPE CASE STUDY

To better explain how TangiDESK can be implemented and used in actual urban design and planning projects, a scenario of an existing local housing project based in Rangsit, Thailand is used as a case study for design schematic development. The housing project is called "Rangsit Thanee" located about 40 kilometers from central Bangkok to the East, and has simple housing project elements such as a single main road, equally divided land parcels, modular homes, a central facility (swimming pool), and public open spaces (landscape).

The entire project is a very long strip piece of land with the main entrance located at one end of the strip. Because of this unique land feature and the size of the tabletop being limited by screen resolution, the strip is deliberately divided into three parts: front; middle; and back, to better match our equipment capacity and for development purposes of the system. This is also similar to project development phases that favor development of the inner most land plots or parcels first in order to increase the value of land plots closer to the front near the main entrance (Figure 4).

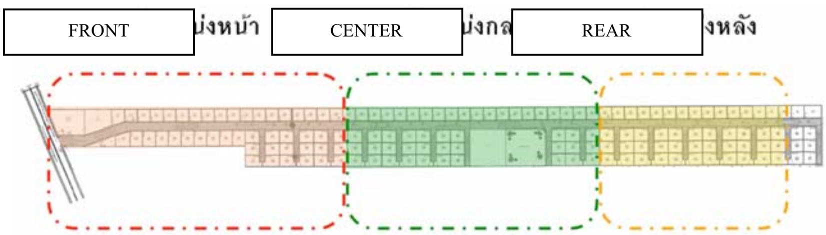


Figure 4. Rangist Thanee Project Master Plan.

5.2. PROTOTYPE IMPLEMENTATION

TangiDESK consists of the four main components as explained earlier with additional building objects and swimming pool object as its physical objects. We use a hard top table and replaced its surface with a matte surface sheet of plexi-glass. The hardware we used consists of an infrared CCD camera, an infrared light source to illuminate the surface from below, a LCD projector, and a PC with 1.5 GHz Core2 Duo processors, 2 Gigabits of RAM, and an NVidia Geforce 5700 graphics card. All equipment, except for the building models with fiducial symbols attached beneath, are located under the tabletop surface as shown in Figure 2. The software applications used are Processing, reacTIVision, and MySQL.

In addition to the tracking of building objects, TangiDESK also employs a semi-intelligent checking system that assists the user in examining building code regulations and construction costs that impact decision-makings of the designer and developer alike. When a building object is added, removed or replaced, the system will automatically check for conflicts in local building code regulations that may occur due to changes in proximity of a building object to the property line, set back line, or other building objects and display in real-time on the table surface (Figure 5).

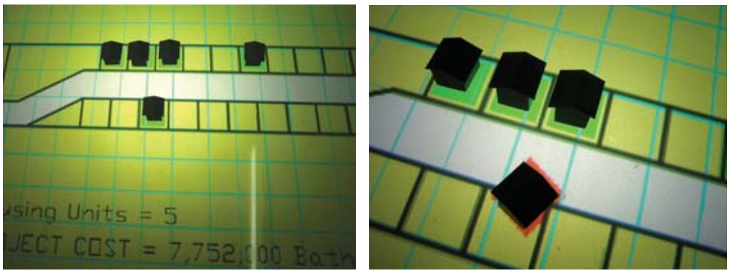


Figure 5. TangiDESK surface with building objects and projected land plots (left). Building code system underlines illegal placement of object with red outline (right).

For example, if the user were to move a certain building beyond the building set back limitation set by the code at a particular project site, then the system will highlight the building in red indicating that the relocation of this building is illegal to execute as a warning to the user. The implementation of the TangiDESK prototype has provided designers and developers a simple way to collaborate with one another and assist both parties in the process of simple design and decision-making tasks such as placing building objects in appropriate locations, summarizing individual and total construction costs, detecting any building code errors, and allowing multiple users to interact with the system simultaneously.

5.3. PRELIMINARY PROTOTYPE EVALUATION

A preliminary study of TangiDESK was conducted with twelve participants consisting of seven architects and five urban planners who were given a brief introduction about the features of the system and the required tasks. These tasks included placing and rearranging building objects on the table, identifying any changes to the construction costs, and detecting any illegal placements of objects according the building code regulations. The participants were then allowed to interact with the system freely and in no particular order to explore its features with no prior training and guidance.

Initial feedback of the system was very positive and encouraging since all participants commented that the system was very easy to use and required no or little explanation to utilize the interface. Also, some urban planners were very eager to manipulate the physical building representations just to observe changes in the costs and feasibility of the project when moving the buildings little by little. Some architects find the system useful for uncovering effective schematic design alternatives without having to wait for feedback from developers and planners.

4.4. PROTOTYPE LIMITATIONS

As in any prototype, TangiDESK was not designed to be a full-featured system that incorporates all decision-oriented constraints needed for both the designer and developer teams. For instance, the current system cannot modify the orientation and direction of the existing road in the project site since the main road inside a project site is one of the first fixed costs of the project that must be predetermined before dividing individual land plots. Both designers and developers must agree with the designated road before utilizing TangiDESK for other design decisions. The prototype also lacks the output mechanism that will transfer the final design into a working drawing since this feature must be thoroughly explored in a limited timeframe.

5. Conclusion and Future Works

This paper presents a tangible user interface prototype called TangiDESK designed to assist designers and developers in decision-making tasks during the early schematic design phase of an urban design project. The prototype consists of four main components, which are the tangible interface, the object recognition component, the graphic representation component, and the database component. We have utilized reacTIVision for object recognition, Processing for graphics and calculations, and MySQL for database. Initial evaluation of the system was encouraging but we need further system adjustments and more user studies to improve user feedback.

However, there is much room for improvement in TangiDESK. For example, adding more useful features and design tasks, recording all activities that occur, employing an output mechanism, providing continuous scrolling or panning to the interface, and adding 3D walk-through simulation features. In addition, the hardware could also be upgraded, industrial grade USB2 or FireWire cameras will provide higher resolution images and frame rates, and more variety of building objects specifically road objects would improve the quality of user interaction for all participants.

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